NAVAL POSTGRADUATE SCHOOL
Monterey, California

EO 3011/EC 3550 FINAL EXAM 12/03 Prof. Powers

- This exam is closed book; notes on 6 sides of 8-1/2 x 11 paper are allowed.
- There are four problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on these exam sheets.
- Exams and course grades: I will email you an announcement when they are ready. They will be on a small table outside the lab door at the top of the stairs.
- If you want me to send you your exam score and course grade, send me an email request. (This request will waive your privacy rights.)
- Enjoy your break!

Course grade: ________________

1		3	
2		4	
TOTAL			

Name: ____

1. Using the vocabulary developed in this course, please provide brief, concise answers to the following questions ...

   (a) What is the primary advantage of single-mode fiber over multimode fiber in a communications link?

   (b) Describe the primary application of an arrayed-waveguide grating in fiber links.

   (c) Explain how Raman scattering can limit performance in an optical fiber link.

   (d) Explain how Raman scattering can be used to have a beneficial effect on the performance of a fiber link.

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2. Short problems ...

   (a) A pin diode operates at 1550 nm. What is the maximum possible value of its responsivity?

   (b) A 50/125 graded-index multimode fiber has $n_1 = 1.450$, $\Delta = 1.5\%$, and $g = 1.959$. Find its cutoff wavelength.

   (c) A fiber with a loss of 0.75 dB/km is 8 km long. Find its effective length.

   (d) A pin diode has a responsivity of 1.0 A/W at 1550 nm and a dark current of 20 nA. Find the value of optical signal power that will make the signal-dependent shot noise equal to 100x the dark-current-dependent shot noise.

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3. Consider a 9/125 single mode fiber with a core index of 1.465 and Δ of 0.2% operating at 1550 nm. The spectral linwidth of the link source is 1.5 nm. The fiber is to be used in a digital link operating at 2.5 Gb/s with NRZ coding. Find the GVD-dispersion-limited link length *(in km)*.

Prob. 4 is on the next page.

4. An optical amplifier, operating at 1550 nm, is to be used in the digital link shown in Fig. 1.

   The source produces 5.0 mW of power in the fiber when a “1” is sent.

   The connector and splice insertion losses are 0.9 dB and 0.2 dB, respectively.

   The fiber loss coefficient is 0.6 dB/km and each fiber “loop” in the figure is 2 km long. Other fiber losses (e.g., fiber “pigtails”) are negligible.

   The amplifier gain is shown in Fig. 2; other properties of the amplifier are given in the table below.

   Using the “dB method” ...

   (a) ... calculate the signal power at the receiver input *in dBm and mW*.

   (b) ... calculate the ASE power at the receiver input *in dBμ and μW*.

Amplifier Properties (Prob. 4)

Parameter	Value
n_{sp}	1.4
$\Delta\lambda_{\text{amplifier}}$	38 nm
B_o	1.4 nm
P_{sat}	0.5 mW

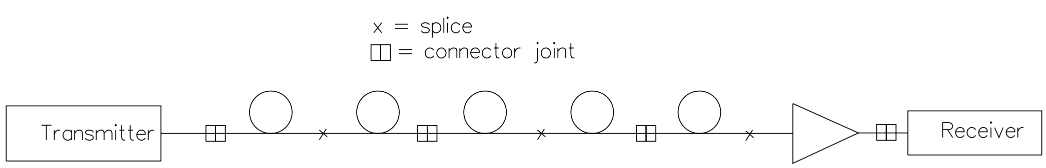


Figure 1: Link configuration for Problem 4.

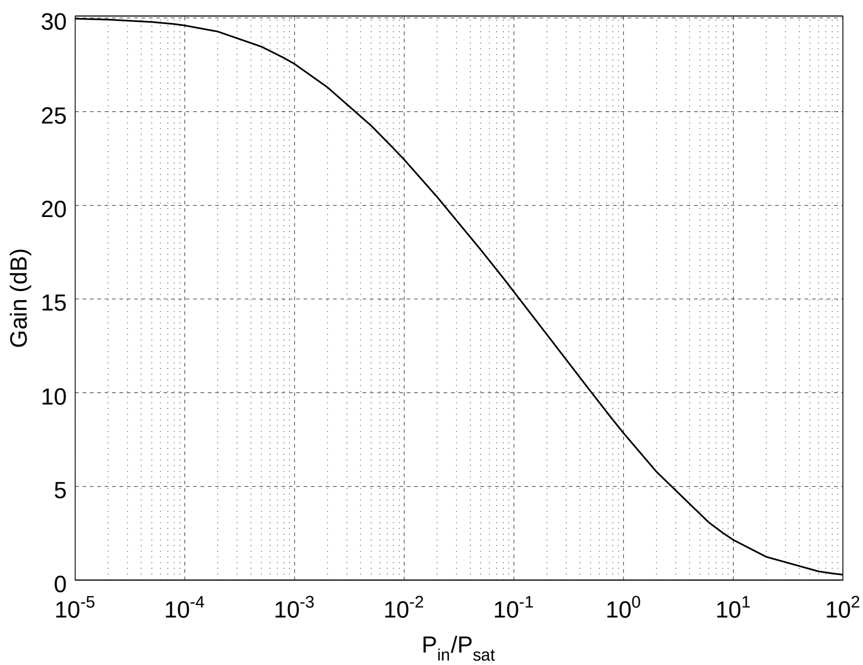
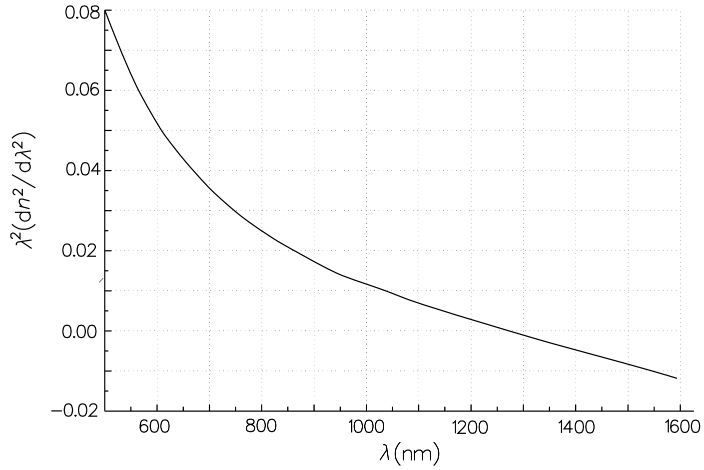
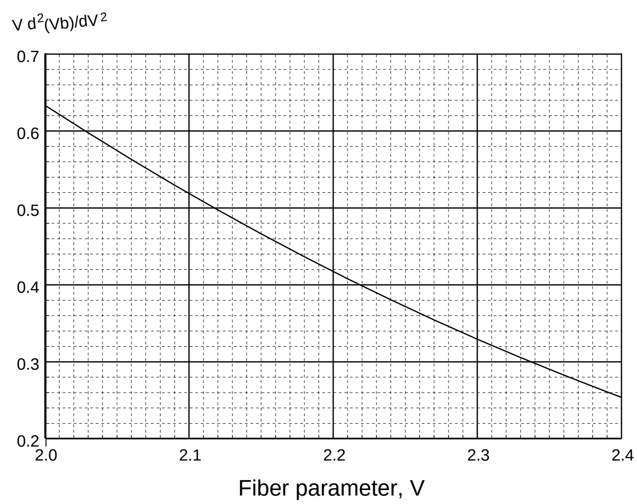


Figure 2: Gain vs. normalized input power of fiber amplifier in Problem 4.



(a)



(b)

Figure 3: (a) Fig. 3.8 and (b) Fig. 3.10 of text.